

# HEALTH-BASED RISK ASSESSMENT REPORT

HAWLEY AUTO BODY AND PAINT  
2902 LYTTON STREET  
SAN DIEGO, CALIFORNIA 92110

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**Unauthorized Release, San Diego County  
File No. H12948-002**

**September 2002**

Submitted to:  
**Site Assessment and Mitigation Division (SAM)**  
County of San Diego  
Department of Environmental Health Services  
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September 30, 2002  
Project No. 200213H

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County of San Diego  
Department of Environmental Health Services  
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P.O. Box 129261  
San Diego, CA 92112-9261

**Re: Health Based Risk Assessment Report  
Hawley Auto Body and Paint  
2902 Lytton Street  
San Diego, California 92110**

On behalf of our client Hawley Auto Body and Paint, D-MAX Engineering, Inc. (D-MAX) is submitting the attached health-based risk assessment report for the subject site. In February of 2002 we recommended closure of this site based on the natural attenuation of the groundwater contamination. In order to consider the site for closure, the SAM division recommended conducting a human health-based risk assessment. This study was conducted based on the recommendations in your letter dated April 10, 2002.

If you any questions regarding this report, please do not hesitate to contact me.

Sincerely,  
D-MAX Engineering, Inc.

Arsalan Dadkhah, Ph.D., P.E.  
Project Manager

cc: Mr. Don Hawley, Hawley Auto Body and Paint

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# 1 EXECUTIVE SUMMARY

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The Hawley Auto Body and Paint site is located at 2844 Lytton Street in San Diego. The site was formerly a gas station, which had leaking underground storage tanks (USTs). Although the tanks were removed in 1997, some contamination still exists in the soil and groundwater in the form of petroleum hydrocarbons and gasoline additives. The purpose of this risk assessment is to evaluate the potential human-health risk associated with the underlying contamination at the site. This assessment was prepared in accordance with the County of San Diego Department of Environmental Health, Site Assessment and Mitigation Division (SAM) Manual (DEHS, 2002).

Since 1997, 99 soil samples and 49 groundwater samples have been analyzed to determine the extent of contamination at the site. Using this data, the approximate extent of contaminated soil has been delineated and the areas of significant groundwater contamination have been identified. The groundwater at the site, and throughout most of the Pueblo San Diego Hydrologic Unit, does not have any beneficial uses listed in the Regional Water Quality Control Board's San Diego Basin Plan.

The primary human-health concern from the existing contamination involves the transport of carcinogenic vapors from the contaminated soil and groundwater into the overlying offices. To evaluate this risk, the Vapor Phase Migration Model provided in the SAM Manual 2002 was utilized using site-specific input parameters. Benzene, the most carcinogenic of gasoline compounds, was used as the chemical of concern.

One of the most determinant parameters used in the vapor phase migration model is the soil gas concentration. In the risk assessment presented herein, soil gas concentrations were calculated using data from monitoring wells MW-2, MW-5 and MW-6, which are the three wells nearest to the office building. The results of the risk assessment modeling indicated cancer risks of  $1.45 \times 10^{-4}$ ,  $9.67 \times 10^{-6}$  and  $2.68 \times 10^{-5}$  using the data obtained from wells MW-2, MW-5, and MW-6, respectively.

Based on the results of the risk assessment calculations, the calculated vapor inhalation cancer risk **is significant**, as it was greater than the acceptable DEH value of  $1.0 \times 10^{-6}$ . These results indicate that the site is not eligible for closure.

## 2 SITE DESCRIPTION AND IDENTIFICATION

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### 2.1 Site Description

The site is located at 2902 Lytton Street, San Diego, California, approximately 200 feet southeast of Rosecrans Street, as shown in Figure 1. This site is bounded on the south by Lytton Street and on the west by an AM/PM mini-mart and Loma Carwash. To the east side of the site is a motorcycle shop, and to the north of the site are apartments and single-family residential properties. A review of the 1975 U.S. Geological Survey (USGS) 7.5 Minute Quadrangle, Point Loma, California topographic map indicates that the site lies at an elevation of approximately 40 feet above mean sea level (MSL). Currently, the site is operated by Donald L. Hawley, Inc. There are two auto mechanic repair shops within the site, including Nationwide Transmission, and Hawley Auto Body and Paint. The owner wishes to maintain the existing land-use of commercial automotive businesses indefinitely.

Currently, there are nine groundwater monitoring wells at the site. Based on the workplan approved by the County of San Diego, these monitoring wells were sampled on a quarterly basis for a period of one year, concluding in February 2002.

### 2.2 Site and Project Identification

- Site Address 2902 Lytton Street  
San Diego, CA 92440
- Name of Business Hawley Auto Body and Paint
- Assessor's parcel number (APN) 450-412-17-00
- SAM Case No. H12948-002
- Property Owner Donald L. Hawley, Inc.  
2844 Lytton Street.  
San Diego, CA 92110  
(619) 222-0371
- UST Owner Donald L. Hawley, Inc.  
2844 Lytton Street.  
San Diego, CA 92110  
(619) 222-0371
- UST Operator Donald L. Hawley, Inc.  
2844 Lytton Street.  
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- Contact Person Donald L. Hawley  
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## 3 SITE HISTORY

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### 3.1 Removal of USTs

On June 17, 1997, Carnevale Construction Management removed a total of five steel underground storage tanks (USTs) along with the dispensers and pipeline materials from the subject site. The USTs included a 500-gallon waste oil tank, a 4,000-gallon diesel fuel tank, a 4,000-gallon gasoline tank, a 5,000-gallon gasoline tank and a 6,000-gallon gasoline tank.

Before the pits were backfilled, several soil samples were collected from the soil underneath the USTs and associated piping and dispenser pumps at different depths as required by SAM. The soil samples under the gasoline and diesel tanks, as well as those underneath the piping systems, were analyzed for TPHg and TPHd. The samples underneath the waste oil tank were analyzed for total recoverable petroleum hydrocarbons (TRPH).

The results of the soil testing indicated a non-detectable concentration of TPH under tank Nos. 1, 2 and 4. One soil sample under Tank No. 3 indicated a TPHg concentration of 94 mg/kg. One soil sample under the waste oil tank indicated a TRPH concentration of 17 mg/kg. Under the piping system, soil sample P4-3 indicated a TPHd concentration of 2,500 mg/kg, and soil sample P6-1.5 indicated a TPHd concentration of 370 mg/kg. The results of the laboratory analysis are tabulated in Table 1.

Upon completion of the analysis, the SAM was informed of the results. Due to the level of petroleum hydrocarbon release, the site was classified as an unauthorized release and was assigned case number H12948-002 by SAM, which also requested further site assessment.

### 3.2 Preliminary Site Assessment

On January 20, 1999, D-MAX Engineering, Inc. conducted an environmental site assessment at the study area. Four boreholes were drilled at the site, designated BH-1 through BH-4 as shown in Figure 2. BH-1 was drilled to the depth of 32 feet, and the rest of boreholes were drilled to a depth of 26 to 26.5 feet below grade surface. Soil samples were collected at five-foot intervals from all boreholes. Groundwater was observed at the depth of 26.5 feet bgs. One groundwater sample was collected from borehole BH-1 from a depth of 30 feet below grade. This water sample was collected using a disposable bailer inserted into a perforated pipe.

A total of 21 soil samples and groundwater samples were submitted to D-TEK Analytical Laboratory for analytical testing in accordance with the guidelines of the SAM Manual.

The tests performed on the soil samples included TPHg for all 21 samples and BTEX on the samples with the highest concentration of TPH at each borehole. The results of the soil chemical analyses are presented in Table 1.

The first five soil samples at borehole BH-1 did not show any concentration of TPHg or TPHd above the laboratory detection limit, but the concentration of TPHg in the soil sample just beneath the groundwater table was 2,230 mg/kg. At this location, benzene concentration was 2.4 mg/kg, toluene concentration was 23.4 mg/kg, ethylbenzene was 17 mg/kg, and total xylene was 79.6 mg/kg.

BH-2 soil samples did not indicate any TPHg concentrations above the laboratory detection limit.

At borehole BH-3, the first three samples at depths 5, 10 and 15 feet below grade indicated non-detected concentrations of TPHg. A soil sample at the depth of 20 feet had a TPHg concentration of 1,290 mg/kg. At this point, benzene concentration was not detected above the laboratory detection limit, toluene concentration was 1.26 mg/kg, ethylbenzene concentration was 0.24 mg/kg, and total xylene concentration was 10 mg/kg.

The first four samples at depths 5, 10, 15 and 20 fbg at borehole BH-4 did not indicate any detectable concentrations of TPHg. The soil sample at the depth of 25 feet bgs indicated a TPH concentration of 3,200 mg/kg. For this sample, the benzene concentration was 1.8 mg/kg, toluene concentration was 19.6 mg/kg, ethylbenzene concentration was 20.0 mg/kg, and total xylene concentration was 84.7 mg/kg.

TPHd was not detected above the laboratory detection limit in any of the 21 soil samples.

A groundwater sample was collected from borehole BH-1. No free product was observed during sampling. The results of the laboratory test indicated a TPH concentration of 79,200 µg/l, benzene concentration of 2,970 µg/l, toluene concentration of 9,800 µg/l, ethylbenzene concentration of 1,990 µg/l, total xylene concentration of 9,300 µg/l and MTBE concentration of 1,260 µg/l. The analytical results are presented in Table 2.

### **3.3 Environmental Site Assessment (February 2000)**

On February 17, 2000, four 2-inch monitoring wells, which were designated as MW-1 through MW-4, were installed at the site.

Two of the wells were installed south and east of the removed USTs. The purpose of these wells was to provide more information regarding the subsurface conditions in the immediate vicinity of the removed USTs and assess the extent of contaminated soil and groundwater in the northwest- southeast direction.

The other two monitoring wells were installed west (upstream) and southeast (downstream) of the impacted area.

The purpose of the upstream monitoring well was to assess the possibility of migration of impacted groundwater from the Arco station to the study area. The Arco station site is located upstream of site and has had groundwater impacted history. The purpose of the downstream monitoring well was to delineate the downstream extent of the impacted groundwater.

At each monitoring well soil samples were collected at every five-foot interval, and a groundwater sample was collected when drilling was complete. During installation of the four monitoring wells, 23 soil samples were collected and submitted to laboratory for analytical testing. All samples were analyzed for TPH at the full carbon range using Modified EPA Method 8015. At each well, the soil sample with the highest concentration of TPH was also analyzed for BTEX and MTBE using EPA Method 8020.

Four groundwater samples (one sample for each well) were collected and submitted to the laboratory for analytical testing. No free product was observed at any of the monitoring wells. All samples were analyzed for TPH at full carbon range in general accordance with Modified EPA Method 8015, as well as for BTEX and MTBE in general accordance with EPA Method 8020.

The soil samples at wells MW-1 and MW-4 indicated no concentration of TPH above the laboratory detected limit. Therefore, samples were not analyzed for BTEX and MTBE. At monitoring well MW-2, the TPHg concentrations of 42.2 and 2,360 mg/kg were detected in samples collected at depths of 20 and 25 feet respectively. The results of the BTEX and MTBE analyses for the sample collected at the depth of 25 fbg indicated a benzene concentration of 112 µg/kg, ethylbenzene concentration of 2,760 µg/kg, and toluene concentration of 2,220 µg/kg; the total xylene concentration was 19,700 µg/kg. MTBE was not detected in this sample.

At monitoring well MW-3, the soil sample at a depth of 25 fbg indicated a TPHg concentration of 1,150 mg/kg. Further analysis for BTEX and MTBE for this sample indicated no detection of benzene concentration, ethylbenzene concentration of 512 µg/kg, toluene concentration of 144 µg/kg and total xylene concentration of 2,080 µg/kg. MTBE was not detected in either sample. The results of soil sample analytical tests are summarized in Table 1.

Groundwater samples were collected from all monitoring wells at the site. No free product was observed during groundwater sampling. The samples were tested for TPH in full carbon ranges, BTEX and MTBE. The analytical results are presented in Table 2.

The groundwater sample from the monitoring well MW-1 showed a trace of benzene of 0.9 µg/l, total xylene of 2.5 µg/l and MTBE concentration of 79.6 µg/l.

No detectable concentration of ethylbenzene, toluene or TPH was reported.

The results of the laboratory tests for the groundwater sample from MW-2 indicated a TPH concentration of 83,200 µg/l, benzene of 5,930 µg/l, ethylbenzene of 1,940 µg/l, toluene of 13,800 µg/l, total xylene of 8,890 µg/l and MTBE of 833 µg/l.

In the groundwater sample from monitoring well MW-3, the concentration of TPHg was 8,240 µg/l, benzene was 19 µg/l, ethylbenzene was 38 µg/l, toluene was 342 µg/l, total xylene was 1,270 µg/l, and MTBE was 94 µg/l.

The groundwater sample from MW-4 indicated no detectable concentration of TPHg, BTEX or MTBE.

### **3.4 Additional Site Assessment (March 2001)**

On January 31, 2001, four additional 2-inch monitoring wells were installed at the site, designated MW-5 through MW-8. MW-5 and MW-6 were installed east and southeast of the previously removed USTs, respectively. MW-7 and MW-8 were installed west and southwest of the removed USTs, respectively. The purpose of these four wells was to further assess lateral and vertical extent of the impacted soil and groundwater at the site in the east and west directions.

During the installation of monitoring well MW-6, it was realized that the collected soil samples were impacted with hydrocarbon products, which indicated that the soil and groundwater delineations were not complete. Another monitoring well, MW-9, was installed on March 7<sup>th</sup>, 2001 to further assess the southeast extent of the contaminated soil and groundwater.

At each monitoring well soil samples were collected at every five-foot interval, and a groundwater sample was collected when drilling was complete. During the installation of the five monitoring wells, 35 soil samples were collected and submitted to D-TEK Laboratory for analytical testing in accordance with the guidelines specified in the 2000 SAM Manual.

The soil samples at wells MW-5, MW-7 and MW-9 indicated no concentration of TPH above the laboratory detection limit. Therefore, samples were not analyzed for BTEX and MTBE. At monitoring well MW-6, TPHg concentrations of 1,645 mg/kg were detected in a sample collected at a depth of 25 feet below grade. The results of the BTEX analyses for the sample indicated an ethylbenzene concentration of 581 µg/kg. Benzene, toluene, total xylene and MTBE were not detected.

At monitoring well MW-8, the soil sample at a depth of 25 fbg indicated a TPHg concentration of 4,090 mg/kg. Further analysis for BTEX and MTBE for this sample indicated an ethylbenzene concentration of 833 µg/kg, toluene concentration of 961 µg/kg and total xylene concentration of 4,710 µg/kg.

Benzene and MTBE were not detected.

TPHd was not detected in either MW- 6 or MW-8. The results of soil analytical tests are presented in Table 1. Based on this data, an estimated area of impacted of soil was delineated and illustrated in Figure 8 of the Additional Environmental Site Assessment Report submitted in March of 2001.

Nine groundwater samples (one for each well) were also collected after drilling was complete. No free product was observed at any of the monitoring wells. Groundwater samples were collected according to the SAM guidelines and submitted to D-TEK Laboratory for analytical testing. The analytical results are presented in Table 2.

The groundwater sample from monitoring well MW-1 showed a concentration of TPHg of 430 µg/ and MTBE of 364 µg/l. Benzene, ethylbenzene, toluene and total xylene were not detected.

The results of the laboratory tests for the groundwater sample from MW-2 indicated a TPHg concentration of 62,000 µg/l, benzene of 4,870 µg/l, ethylbenzene of 1,750 µg/l, toluene of 10,200 µg/l and total xylene of 9,360 µg/l. MTBE was not detected.

In the groundwater sample from monitoring well MW-3, the concentration of TPHg was 7,000 µg/l, ethylbenzene was 330 µg/l, and total xylene was 742 µg/l. Benzene, toluene and MTBE were not detected.

The groundwater sample for monitoring wells MW-4 did not indicate any TPH, BTEX or MTBE concentrations beyond the detection limit.

In the groundwater sample from monitoring well MW-5, the concentration of TPHg was 13,100 µg/l, benzene was 1,620 µg/l, ethylbenzene was 421 µg/l, toluene was 1,650 µg/l, and total xylene was 2,300 µg/l. MTBE was not detected.

The results of the laboratory tests for the groundwater sample from MW-6 indicated a TPHg concentration of 28,900 µg/l, benzene of 990 µg/l, ethylbenzene of 868 µg/l, toluene of 4,080 µg/l and total xylene of 4,050 µg/l. MTBE was not detected.

The groundwater sample from MW-7 indicated a TPHg concentration of 6,180 µg/l, benzene of 4.2 µg/l, total xylene of 168 µg/l and a MTBE concentration of 3.7 µg/l. Ethylbenzene and toluene concentrations were non detect.

The groundwater sample from MW-8 indicated a TPHg concentration of 1,050 µg/l, total xylene of 19.7 µg/l, and a MTBE concentration of 2.3 µg/l. Benzene, ethylbenzene and toluene were not detected.

The groundwater sample from monitoring well MW-9 indicated no concentration of TPH, benzene ethylbenzene, total xylene or MTBE. The only detected concentration in this monitoring well was a trace of toluene at 1.1 µg/l.

### **3.5 Quarterly Groundwater Monitoring (2001-2002)**

In accordance with the workplan dated July 10, 2000, groundwater from all nine wells was monitored on a quarterly basis between February 2001 and February 2002. Monitoring wells MW-1 through MW-4 were also sampled once in February of 2000, just after the construction of these wells. Results from the past two years of groundwater monitoring at the site are presented in Table 2.

During the past two years of groundwater monitoring at the site, the overall pollutant concentrations have not exhibited an easily discernible trend throughout the site. This is evident in TPHg concentrations presented in Table 2. Specific monitoring wells (MW-5, MW-6, and MW-7) have shown consistent decreases in certain pollutants, however, results from other wells have been more challenging to interpret. Although a significant decrease of pollutant concentrations was measured at all sampling locations during the May 2001 sampling event, concentrations increased again in August 2001. D-MAX believes the data from May 2001 is inconsistent with the rest of the collected data, and for the sake of presenting an accurate overall summary of the monitoring results, the May 2001 data has been considered with less importance. Summaries of past results from individual monitoring wells are presented below.

MW-1 is located upstream of the primary contaminated area. Results from this well have shown consistently detectable levels of MTBE and small amounts of TPHg, but negligible concentrations of other pollutants. It is believed that this may be caused by either upstream advection of pollutants, or downstream contamination from the ARCO gas station adjacent to the site. This particular ARCO has had previous groundwater contamination problems with high MTBE concentrations detected at a nearby monitoring well to MW-1. The potential for contamination from the ARCO facility is further described in the report dated March 2001. During the most recent sampling, a decrease in MTBE concentration was observed.

MW-2 is located nearest to the center of the area where the previous USTs were excavated. Pollutant concentrations from this location have been shown to steadily decrease until November 2001, when a subtle increase in BTEX constituents and a sharp increase in TPHg were detected. The most recent measurements showed slightly increased concentrations of BTEX constituents and decreased TPHg. MTBE concentrations have decreased below the detection limit of analysis.

MW-3 is located to the south at approximately similar groundwater elevation as the primary area of contamination. Results from the site have shown inconsistent data. The most recent monitoring results showed increased concentrations of TPHg, while benzene, toluene and MTBE have decreased below the detection limit.

MW-4 is located on the southeastern portion of the site and is laterally downstream from the primary area of contamination. This site has shown no sign of contamination since monitoring began.

MW-5 is located directly downstream of the primary area of contamination. This site has shown a consistent decrease in pollutant concentrations, although a small increase was observed in November of 2001. The February 2002 results showed decreased concentrations of all contaminants including benzene and TPHg; MTBE concentration has decreased below the detection limit of analysis.

MW-6 is also located directly downstream of the primary area of contamination. The site has shown consistent decreases in contamination of all BTEX contaminants. TPHg has also shown an overall decreasing trend with less consistent results.

MW-7 is located upstream of the primary area of contamination and has shown a general decreasing trend in overall contamination. A peak in TPHg and ethylbenzene concentrations was observed in August 2001, which has been decreasing since. During the most recent sampling benzene and MTBE have decreased below the detection limit of the analysis.

MW-8 is located laterally south at approximately similar groundwater elevation as the primary area of contamination. A peak in TPHg was observed in November 2001, which has decreased since. The most recent results showed concentrations of toluene and xylene in negligible amounts, while benzene and MTBE has decreased below the detection limit.

MW-9 is located laterally downstream of the primary area of contamination. This site has shown no sign of contamination.

Overall, it is believed that the contaminated plume is migrating primarily in the direction of the flow gradient (East-northeast) via convection, but has not yet been detected in the downstream eastern monitoring well (MW-9). The plume has not migrated laterally to the south based on the data collected from MW-4. Limited migration may have occurred upstream based on the MTBE data obtained from MW-1, however, this data may also be a result of contamination from the nearby ARCO gas station.

## 4 GEOLOGY AND HYDROGEOLOGY

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The hydrologic setting for the site can be characterized in terms of local topographic expression, surface water and underlying soil and groundwater conditions as follows:

### 4.1 Topography

A review of the local topography map published by the USGS indicates the site has an approximate elevation of 40 feet above mean sea level; the ground surface in the nearby area slopes to the southeast.

### 4.2 Surface Water

Surface water at the site is limited to storm water runoff generated during storm events. Surface water runoff is directed to street gutters, which drain through a subterranean storm pipe into the San Diego Bay less than one-half mile southeast of the site.

### 4.3 Site Geology

According to the map entitled "Geology of the Point Loma Quadrangle, San Diego County, California" published by the California Division of Mines and Geology (Kennedy, 1975), the site area is underlain at the surface by the Bay Point Formation, a poorly consolidated, fine and medium grained, pale brown sandstone deposited in the Pleistocene. The older (Eocene) sediments of the Mount Solidad Formation are mapped at a locality approximately 1000 feet northwest of the site, and this unit may underlie the Bay Point Formation in the area. The site and the surrounding areas have been largely developed; therefore no nearby-undisturbed outcrops were available for visual inspection. Visual logging of boreholes, as well as a review of available geologic maps and reports, verified the site geology.

Two subsurface cross-sections have been drawn and were included as Figures 4 and 5 in the Additional Environmental Site Assessment Report, submitted in March of 2001.

### 4.4 Hydrogeology

According to the Water Quality Control Plan, San Diego Basin (CRWQCB, 1994), the site lies within the boundaries of the Point Loma Hydrologic Area (8.10) of the Pueblo San Diego Hydrologic Unit. Area 8.10 does not have any listed beneficial uses and has been designated as an exception to the municipal use provision of the Basin Plan because beneficial uses in the portions of the basin do not currently exist and are not likely to exist in the future.

During the preliminary site assessment in January 1999, groundwater was encountered at 26.4 feet below the ground surface. During the February 2000 site assessment, the groundwater depth was encountered at the depth of 28.70 feet at monitoring well MW-1, where the land elevation is the highest within the site. The groundwater depth was between 26.26 to 25.86 fbg around the removed USTs (monitoring wells MW-2 and MW-3). Finally, the groundwater depth was 22.9 fbg at monitoring well MW-4, where the ground elevation is the lowest within the site.

During the February 2001 site assessment, the groundwater depth was between 21.10 and 28.70 fbg.

During the most recent sampling in February of 2002, the groundwater depth varied between 21.12 fbg at MW-9, where the ground elevation is the lowest, to 28.65 fbg at MW-1, where the ground elevation is the highest. The groundwater flow direction was calculated to the east with an approximate average gradient of 0.0014 ft/ft.

## 5 EXPOSURE ASSESSMENT

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Exposure is defined as the contact of a receptor with a chemical or physical agent. The exposure assessment determines the quantities or concentrations of the chemicals received by the receptors and evaluates the risks associated with such exposure. Exposure assessments generally are performed by determining the concentrations of chemicals in a medium at a location of interest and linking this information with the time that a population is in contact with the chemicals. Exposure assessment also involves estimating human exposures from multiple routes such as ingestion, dermal contact, and inhalation. As a regulatory default, the DEH considers  $1 \times 10^{-6}$ , or one in one million, to be the acceptable level of insignificant risk for commercial and residential uses.

For this study, the vapor-phase migration pathway was considered to be the only potentially complete pathway. The worst-case scenario of potential human exposure to the contaminants via inhalation for the site is the vertical diffusion of benzene through soil gas and indoor air. Therefore, the following discussion will focus on the vapor phase migration of benzene into the indoor air of a nearby office building, and the exposure of employees to the contaminant via inhalation. Although other buildings do exist on the property, primarily open automotive garages, these were not considered risk areas due to the constant ventilation which occurs throughout the day.

### 5.1 Vapor Phase Migration Modeling

This subsection presents the equations used to estimate the soil gas concentration, effective air diffusion coefficient, diffusive vapor flux, and indoor air concentration. These equations are included in the Vapor Phase Migration Model developed by the Vapor Phase Migration Technical Group (SAM Manual 2002).

#### 5.1.1 Soil Gas Concentrations

For groundwater with dissolved contamination without the presence of non-aqueous phase liquid (NAPL), the standard equation to calculate the soil gas concentration is based on the Henry's Law Constant and is as follows:

$$C_{sg} = C_w * H \text{ (mg/m}^3\text{)}$$

Where:

$C_{sg}$  = Soil gas concentration (mg/m<sup>3</sup>)

$H$  = Henry's law constant (dimensionless), 0.23 for benzene

$C_w$  = Concentration in pore water from monitoring wells (µg/L)

In this risk assessment calculation, we utilized the pore water benzene concentrations from three different monitoring wells in the vicinity of the office building (MW-2, MW-5 and MW-6) and calculated the associated risks from each well. In February of 2002, monitoring wells MW-2, MW-5 and MW-6 showed benzene concentrations of 3,490 µg/L, 232 µg/L and 642 µg/L, respectively. Using these dissolved benzene concentrations, the soil gas concentrations were determined to be 802.70 mg/l, 53.36 mg/l and 147.66 mg/l at MW-2, MW-5, and MW-6, respectively.

### 5.1.2 Calculation of Flux

Soil gas diffusion from the source area to the base of the structure is defined as soil gas flux. The soil gas flux in the study area was calculated based on the following equation:

$$\text{Flux} = \frac{D_e * C_{sg}}{X} * 0.36$$

Where:

Flux of contaminant (mg/hr-m<sup>2</sup>)  
 $D_e$  = Effective diffusion coefficient (m<sup>2</sup>/hr)  
 $X$  = Depth to contamination in vadose zone (m)  
 $C_{sg}$  = Soil gas concentration calculated above

The value for the effective diffusion coefficient ( $D_e$ ) is calculated by using the following equation:

$$D_e = \frac{D_a * P_a^{3.33}}{P_t^2}$$

Where:

$D_a$  = Contaminant diffusion coefficient in air (m<sup>2</sup>/hr)  
 $P_a$  = Air filled porosity (dimensionless)  
 $P_t$  = Total soil porosity (dimensionless)

The effective diffusion coefficient was calculated to be 0.006388 m<sup>2</sup>/hr using an air filled porosity of 0.3, a total porosity of 0.3 and a air diffusion coefficient of 0.088cm<sup>2</sup>/sec. Using the calculated effective diffusion coefficient and a depth to contamination of 6.096 meters, the vapor flux was calculated to be 0.8411 mg/hr-m<sup>2</sup>, 0.0559 mg/hr-m<sup>2</sup> and 0.1547 mg/hr-m<sup>2</sup> at wells MW-2, MW-5 and MW-6, respectively.

### 5.1.3 Indoor Air Concentration

The maximum indoor air concentration was estimated from the following equation:

$$C_i = \frac{\text{Slab} * \text{Flux}}{\text{Height} * E}$$

Where:

$C_i$  = indoor air concentration ( $\mu\text{g}/\text{m}^3$ )  
Slab = Slab attenuation factor (unitless)  
Height = Room height (m)  
E = Indoor air exchange rate per hour (1/hr)

For this calculation, conservative default values were used to represent the site conditions. The slab attenuation factor was estimated at 0.1, height was estimated at 2.44 meters and the indoor air exchange rate was 0.83 exchanges per hour. Using these values, the indoor air concentration was calculated to be 0.04153  $\text{mg}/\text{m}^3$ , 0.00276  $\text{mg}/\text{m}^3$  and 0.00764  $\text{mg}/\text{m}^3$  at wells MW-2, MW-5, and MW-6, respectively.

## 5.2 Quantification of Exposure and Risk

Exposure point concentrations are the chemical concentrations contacted at a location over the exposure period. In this health-based risk assessment, the exposure point concentration is the indoor air concentration of benzene in the office building. In order to evaluate the risk, the indoor air concentration is used to quantify the chemical intake of a contaminant by a receptor.

### 5.2.1 Chemical Intake

To calculate the risk to a receptor or individual from specific exposure (intake), the following equation is used:

$$\text{Intake} = \frac{C_i * IR * ET * EF * ED}{BW * AT}$$

Where:

Intake = Vapor phase intake ( $\text{mg}/\text{kg}\text{-day}$ )  
 $C_i$  = Indoor air concentration ( $\text{mg}/\text{m}^3$ )  
IR = Inhalation rate ( $\text{m}^3/\text{day}$ )  
ET = Exposure time (hr/24hr)  
EF = Exposure frequency (days/yr)

ED = Exposure duration (yr)  
BW = Body weight (kg)  
AT = Averaging time (days)

In this risk assessment, the following standard default values were used during the intake calculation:

IR = 20 m<sup>3</sup>/day  
ET = 0.5 hr/24hr  
EF = 250 days/year  
ED = 25 years  
BW = 70 kg  
AT = 25500 days

The chemical intake was calculated to be  $1.45 \times 10^{-3}$  mg/kg-day,  $9.67 \times 10^{-5}$  and  $2.68 \times 10^{-4}$  using data from wells MW-2, MW-5 and MW-6, respectively.

### 5.2.2 Risk

To calculate the risk, the intake is applied to the cancer slope factor for the compound of concern. The risk is calculated as:

Risk = Intake \* Slope factor

The cancer slope factor for benzene vapor inhalation is 0.1. Thus, the calculated risks are  $1.45 \times 10^{-4}$ ,  $9.67 \times 10^{-6}$  and  $2.68 \times 10^{-5}$  using the data obtained from wells MW-2, MW-5, and MW-6, respectively.

Summaries of the calculated risks for each monitoring well showing all input parameters are presented in Tables 3, 4 and 5. A brief summary of the risks associated with monitoring wells MW-2, MW-5 and MW-6, including the soil gas concentration and indoor air concentration, is presented in the table below.

Monitoring Well	Soil Gas Concentration (mg/L)	Indoor Air Concentration (mg/m <sup>3</sup> )	Risk
MW-2	802.70	0.04153	$1.45 \times 10^{-4}$
MW-5	53.360	0.00276	$9.67 \times 10^{-6}$
MW-6	147.660	0.00764	$2.68 \times 10^{-5}$

## 6 RESULTS AND RECOMMENDATIONS

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The results of the risk assessment modeling indicated cancer risks of  $1.45 \times 10^{-4}$ ,  $9.67 \times 10^{-6}$  and  $2.68 \times 10^{-5}$  using the data obtained from wells MW-2, MW-5, and MW-6, respectively. Based on these results, the calculated vapor inhalation cancer risk **is significant**, as it was greater than the acceptable DEH value of  $1.0 \times 10^{-6}$ . These results indicate that the site is not eligible for closure.

We recommend to continue conducting quarterly groundwater monitoring at the nine wells and to reassess the risk at a later date.

**TABLE 1**  
**SOIL SAMPLE ANALYTICAL SUMMARY**

**TABLE 2**  
**GROUNDWATER SAMPLE ANALYTICAL SUMMARY**

All concentrations in µg/l

Sample Location	Sampling Date	TPHg <sup>1</sup>	Benzene <sup>2</sup>	Ethylbenzene <sup>2</sup>	Toluene <sup>2</sup>	Total Xylene <sup>2</sup>	MTBE <sup>3</sup>
MW-1	2/25/00	nd <sup>4</sup>	0.9	nd	nd	2.5	79.6
	2/5/01	430	nd	nd	nd	nd	364
	5/14/01	609	nd	nd	nd	nd	347
	8/20/01	31	nd	nd	nd	nd	409
	11/12/01	nd	nd	nd	nd	nd	458
	02/18/02	135	nd	nd	nd	nd	395
MW-2	2/25/00	83,200	5,930	1,940	13,800	8,890	833
	2/5/01	62,000	4,870	1,750	10,200	9,360	nd
	5/14/01	14,600	2,130	nd	3,600	4,410	nd
	8/21/01	53,100	2,450	942	4,760	4,620	nd
	11/13/01	94,500	3,110	1,250	7,500	5,160	nd
	02/19/02	73,000	3,490	1,310	8,150	6,550	nd
MW-3	2/25/00	8,240	19	38	342	1,270	94
	2/5/01	7,000	nd	330	nd	742	nd
	5/14/01	106	nd	nd	nd	nd	nd
	8/21/01	12,500	nd	222	nd	561	nd
	11/12/01	2,430	nd	39.3	nd	37.9	nd
	02/19/02	9,200	nd	165	nd	340.5	nd
MW-4	2/25/00	nd	nd	nd	nd	nd	nd
	2/5/01	nd	nd	nd	nd	nd	nd
	5/14/01	nd	nd	nd	nd	nd	nd
	8/20/01	nd	nd	nd	nd	nd	nd
	11/12/01	nd	nd	nd	nd	nd	nd
	02/18/02	nd	nd	nd	nd	nd	nd
MW-5	2/5/01	13,100	1,620	421	1,650	2,300	nd
	5/14/01	726	19.9	nd	1.10	260.6	19.6
	8/21/01	9,280	522	168	593	763	16.1
	11/13/01	14,300	708	263	927	990	20.7
	02/19/02	5,400	232	78.4	314	394	nd
MW-6	2/5/01	28,900	990	868	4,080	4,050	nd
	5/14/01	6,880	85.0	nd	nd	2,205	70
	8/21/01	41,300	1,420	845	4,290	2,760	124
	11/13/01	23,700	654	521	1,870	1,315	93.0
	02/19/02	24,000	642	464	1,430	1,355	97.2
MW-7	2/5/01	6,180	4.2	nd	nd	168	3.7
	5/14/01	1,090	2.4	nd	nd	20.3	nd
	8/21/01	17,800	3.9	121	2.0	83.8	nd
	11/12/01	11,600	1.3	38.2	nd	14.0	nd
	02/18/02	5,600	nd	18.6	1.0	9.3	nd
MW-8	2/5/01	1,050	nd	nd	nd	19.7	2.3
	5/14/01	97.0	nd	nd	nd	nd	nd
	8/20/01	2,960	nd	11.7	nd	2.3	nd
	11/12/01	5,830	nd	36.3	nd	4.3	nd
	02/18/02	1,890	nd	7.1	1.1	1.1	nd
MW-9	3/12/01	nd	nd	nd	1.1	nd	nd
	5/14/01	nd	nd	nd	nd	3.4	nd
	8/20/01	nd	nd	nd	nd	nd	nd
	11/12/01	nd	nd	nd	nd	nd	nd
	02/18/02	nd	nd	nd	nd	nd	nd

**TABLE 3**  
**VAPOR INHALATION RISK ASSESSMENT CALCULATION**  
**FOR MONITORING WELL MW-2**

Soil Gas Calculation		
Cw	3490	Concentration of compound in groundwater at MW-2 on 2/19/02 (ug/L)
H	0.23	Henry's Law Constant
<b>Csg = Cw * H</b>	<b>802.700 mg/l</b>	<b>Soil Gas Concentration</b>
Flux Calculation		
Da	0.088	Contaminant diffusion coefficient in air (cm <sup>2</sup> /hr)
Pa	0.3	Air filled porosity
Pt	0.3	Total soil porosity
De = Da*Pa <sup>3.33</sup> /Pt <sup>2</sup> =	0.017744 cm <sup>2</sup> /sec	Effective Diffusion Coefficient (m <sup>2</sup> /hr)
X	6.096	Depth to contamination in vadose zone (m)
<b>Fx (De*Csg/X)*(3600/10000) =</b>	<b>0.8411 mg/hr m<sup>2</sup></b>	<b>Flux</b>
Indoor Air Concentration		
Slab	0.1	Slab attenuation Factor
Height	2.44	Room height (m)
E	0.83	Indoor air exchange rate per hour (1/hr)
<b>Ci Slab*Flux/(Height*E) =</b>	<b>0.04153334 mg/m<sup>3</sup></b>	<b>Indoor air concentration (mg/m<sup>3</sup>)</b>
Chemical Intake (IT)		
IR	20	Inhalation Rate (m <sup>3</sup> /day)
ET	0.5	Exposure time (hr/24)
EF	250	Exposure Frequency (days/yr)
ED	25	Exposure Duration (yr)
BW	70	Body Weight (kg)
AT	25500	Averaging Time (days)
<b>IT = (Ci*IR*ET*EF*ED)/(BW*AT) =</b>	<b>1.45E-03</b>	<b>Vapor Phase Intake (mg/kg-day)</b>
Risk Calculation		
Slope Factor	0.1	
<b>Risk = Intake*Slope Factor =</b>	<b>1.45E-04</b>	<b>Calculated Risk</b>

**TABLE 4**  
**VAPOR INHALATION RISK ASSESSMENT CALCULATION**  
**FOR MONITORING WELL MW-5**

Soil Gas Calculation			
Cw	232	Concentration of compound in groundwater at MW-5 on 2/19/02 (ug/L)	
H	0.23	Henry's Law Constant	
<b>Csg = Cw * H</b>		<b>53.360 mg/l</b>	<b>Soil Gas Concentration</b>
Flux Calculation			
0.01	0.088	Contaminant diffusion coefficient in air (cm <sup>2</sup> /hr)	
Pa	0.3	Air filled porosity	
Pt	0.3	Total soil porosity	
De = Da*Pa <sup>3.33</sup> /Pt <sup>2</sup> =		0.017744 cm <sup>2</sup> /sec	Effective Diffusion Coefficient (m <sup>2</sup> /hr)
X	6.096	Depth to contamination in vadose zone (m)	
<b>Fx (De*Csg/X)*(3600/10000) =</b>		<b>0.0559 mg/hr m<sup>2</sup></b>	<b>Flux</b>
Indoor Air Concentration			
Slab	0.1	Slab attenuation Factor	
Height	2.44	Room height (m)	
E	0.83	Indoor air exchange rate per hour (1/hr)	
<b>Ci Slab*Flux/(Height*E) =</b>		<b>0.00276096 mg/m<sup>3</sup></b>	<b>Indoor air concentration (mg/m<sup>3</sup>)</b>
Chemical Intake (IT)			
IR	20	Inhalation Rate (m <sup>3</sup> /day)	
ET	0.5	Exposure time (hr/24)	
EF	250	Exposure Frequency (days/yr)	
ED	25	Exposure Duration (yr)	
BW	70	Body Weight (kg)	
AT	25500	Averaging Time (days)	
<b>IT = (Ci*IR*ET*EF*ED)/(BW*AT) =</b>		<b>9.67E-05</b>	<b>Vapor Phase Intake (mg/kg-day)</b>
Risk Calculation			
Slope Factor	0.1		
<b>Risk = Intake*Slope Factor =</b>		<b>9.67E-06</b>	<b>Calculated Risk</b>

**TABLE 5**  
**VAPOR INHALATION RISK ASSESSMENT CALCULATION**  
**FOR MONITORING WELL MW-6**

Soil Gas Calculation			
Cw	642	Concentration of compound in groundwater at MW-6 on 2/19/02 (ug/L)	
H	0.23	Henry's Law Constant	
<b>Csg = Cw * H</b>		<b>147.660 mg/l</b>	<b>Soil Gas Concentration</b>
Flux Calculation			
0.01	0.088	Contaminant diffusion coefficient in air (cm <sup>2</sup> /hr)	
Pa	0.3	Air filled porosity	
Pt	0.3	Total soil porosity	
De = Da*Pa <sup>3.33</sup> /Pt <sup>2</sup> =		0.017744 cm <sup>2</sup> /sec	Effective Diffusion Coefficient (m <sup>2</sup> /hr)
X	6.096	Depth to contamination in vadose zone (m)	
<b>Fx (De*Csg/X)*(3600/10000) =</b>		<b>0.1547 mg/hr m<sup>2</sup></b>	<b>Flux</b>
Indoor Air Concentration			
Slab	0.1	Slab attenuation Factor	
Height	2.44	Room height (m)	
E	0.83	Indoor air exchange rate per hour (1/hr)	
<b>Ci Slab*Flux/(Height*E) =</b>		<b>0.00764023 mg/m<sup>3</sup></b>	<b>Indoor air concentration (mg/m<sup>3</sup>)</b>
Chemical Intake (IT)			
IR	20	Inhalation Rate (m <sup>3</sup> /day)	
ET	0.5	Exposure time (hr/24)	
EF	250	Exposure Frequency (days/yr)	
ED	25	Exposure Duration (yr)	
BW	70	Body Weight (kg)	
AT	25500	Averaging Time (days)	
<b>IT = (Ci*IR*ET*EF*ED)/(BW*AT) =</b>		<b>2.68E-04</b>	<b>Vapor Phase Intake (mg/kg-day)</b>
Risk Calculation			
Slope Factor	0.1		
<b>Risk = Intake*Slope Factor =</b>		<b>2.68E-05</b>	<b>Calculated Risk</b>